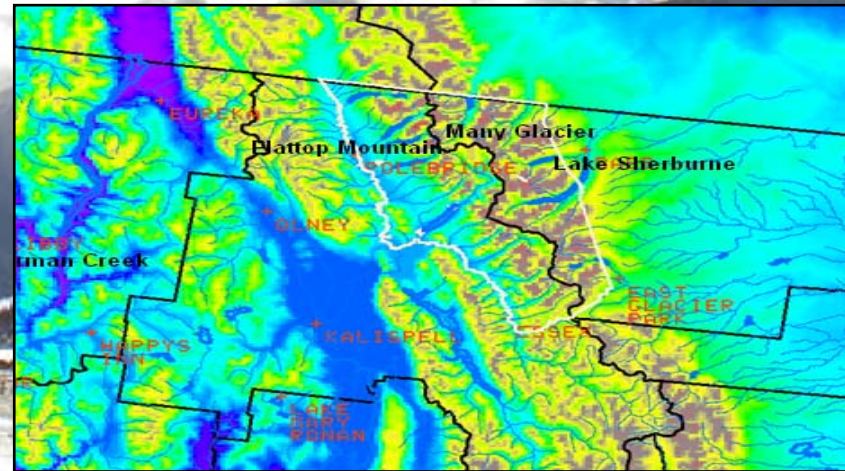


Flooding in Glacier National Park November 2006

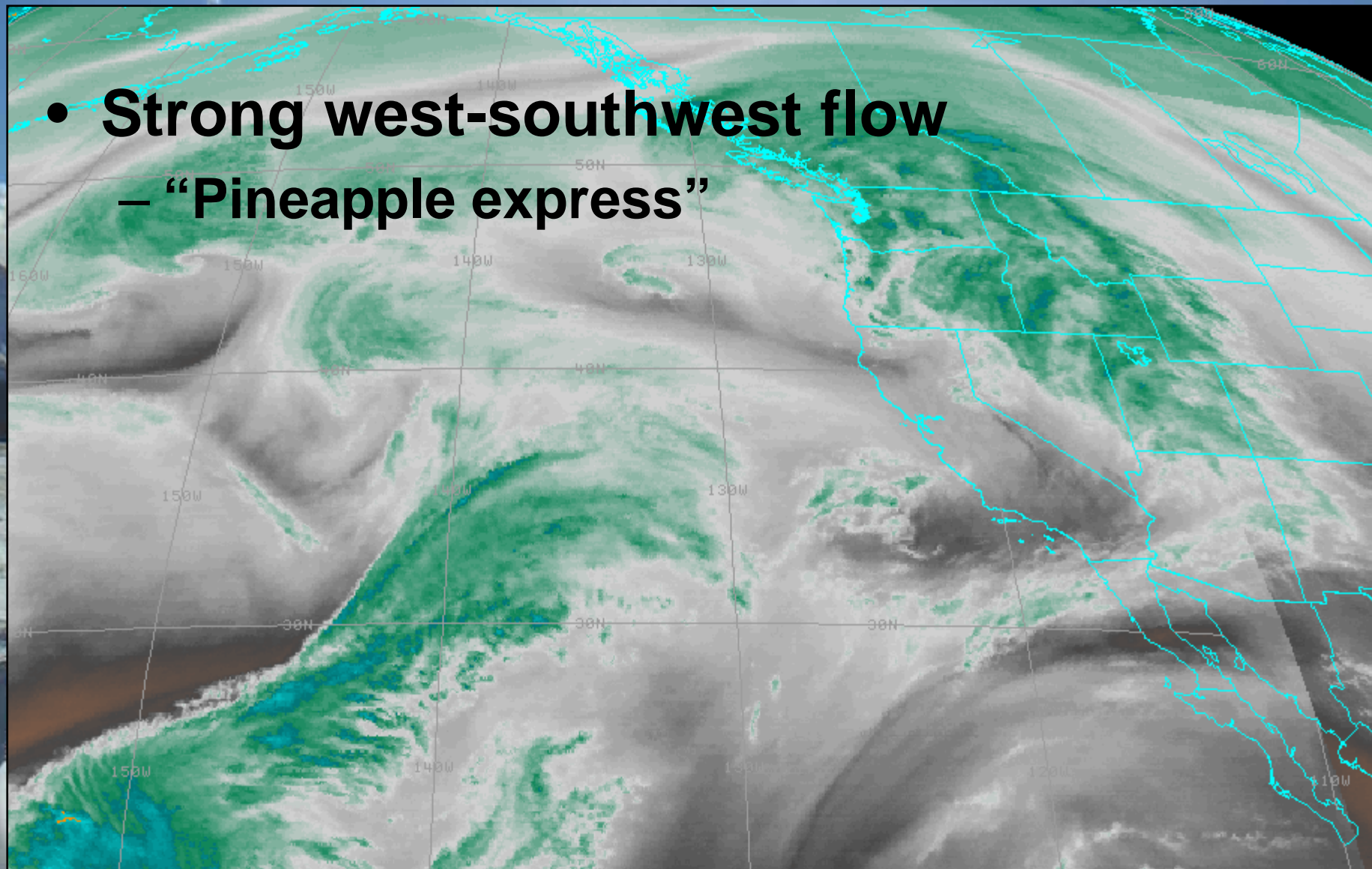


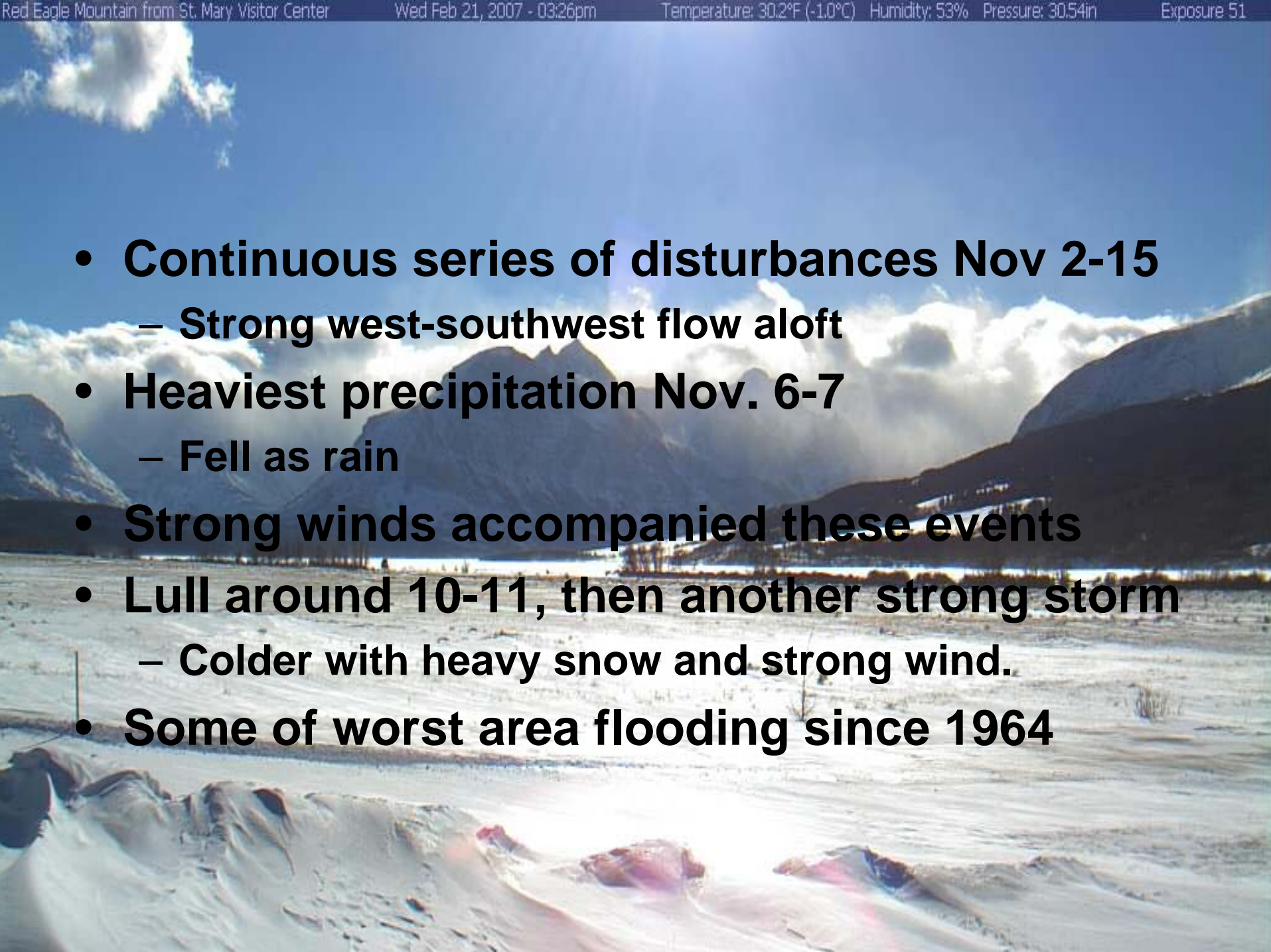
NPS, 2006

- What was weather setup during greatest precipitation intensity?
 - Why did it happen?
- Weather information
 - Precipitation
 - Temperature/Wind
- River gauges
- Monitoring atmospheric moisture
- Pictures



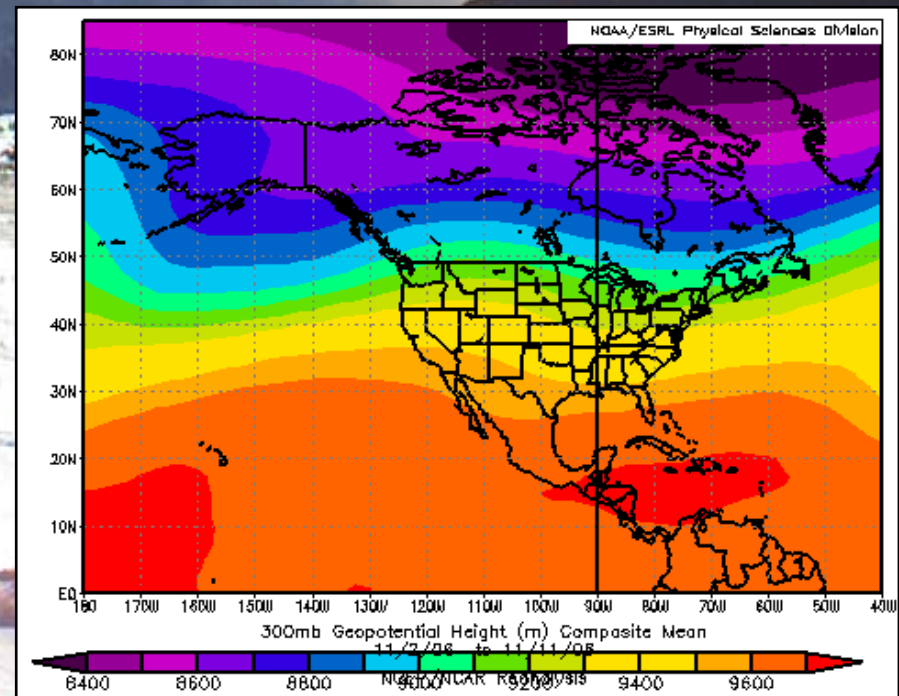
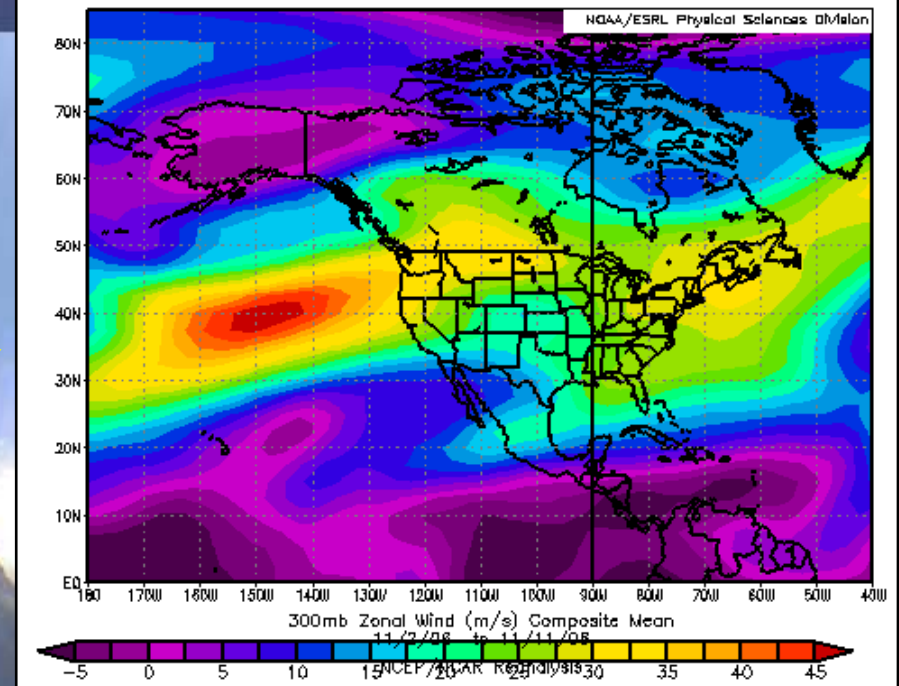
- **Strong west-southwest flow**
– **“Pineapple express”**



- 
- **Continuous series of disturbances Nov 2-15**
 - Strong west-southwest flow aloft
 - **Heaviest precipitation Nov. 6-7**
 - Fell as rain
 - **Strong winds accompanied these events**
 - **Lull around 10-11, then another strong storm**
 - Colder with heavy snow and strong wind.
 - **Some of worst area flooding since 1964**

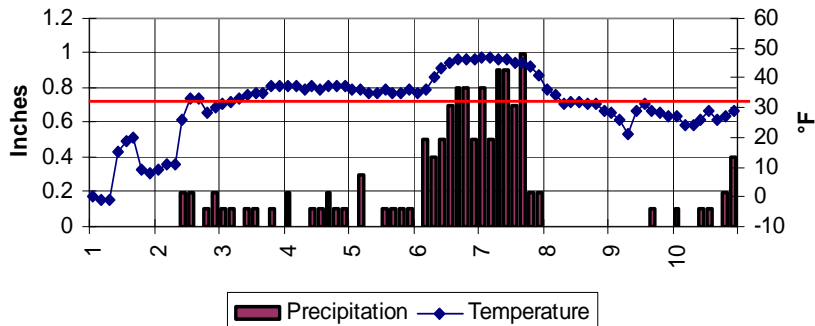
- Strong west-southwest flow

- Persistent through period

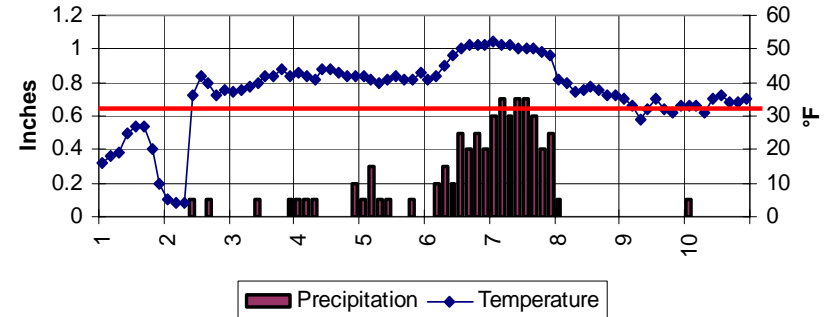


Warm during precipitation

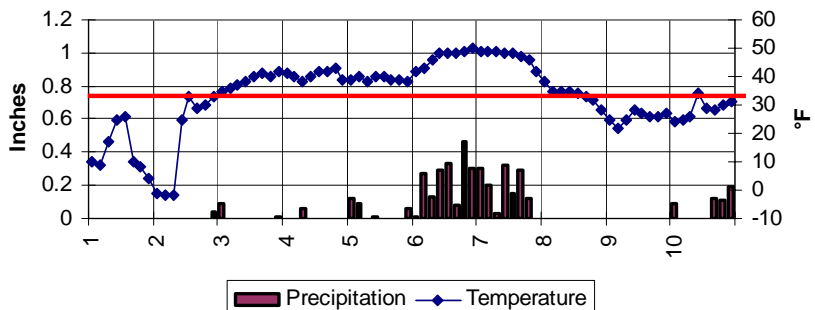
Temperature and Precipitation at Flattop Mountain
SNOTEL (elev. 6300 ft)
November 1-10, 2006



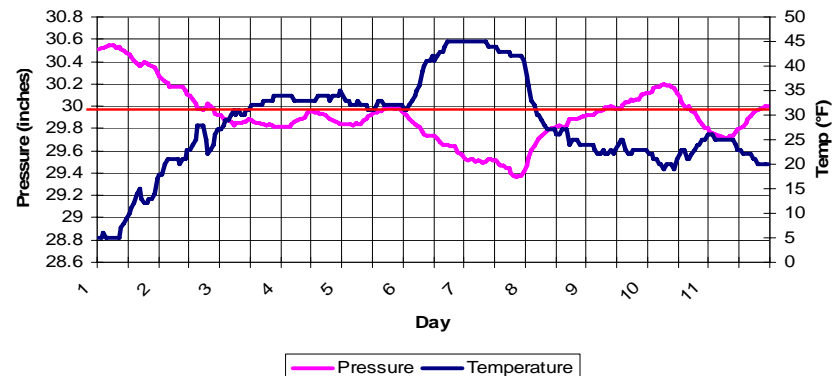
Temperature and Precipitation at Many Glacier
SNOTEL (elev. 4900 ft)
November 1-10, 2006



Temperature and Precipitation at Summit
(elev. 5233 ft)
November 1-10, 2006

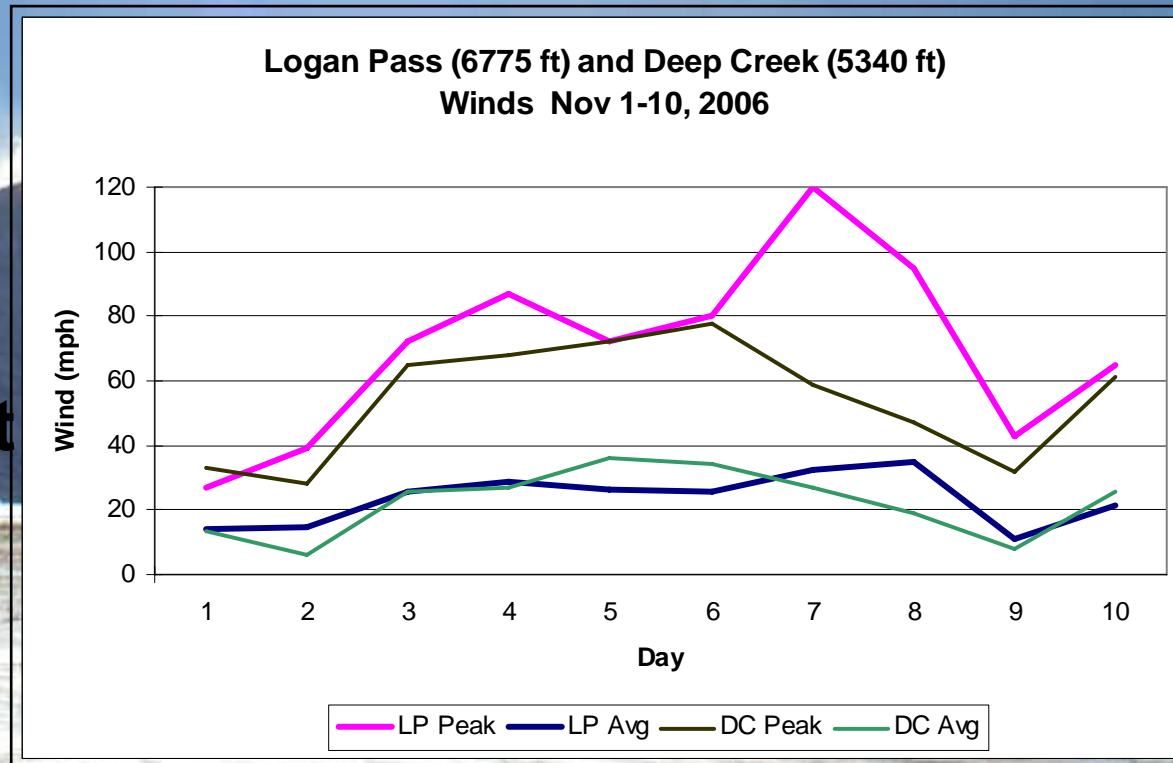


Logan Pass Temperature and Pressure
Nov 1-11, 2006 (elev. 6775 ft)



Windy, too

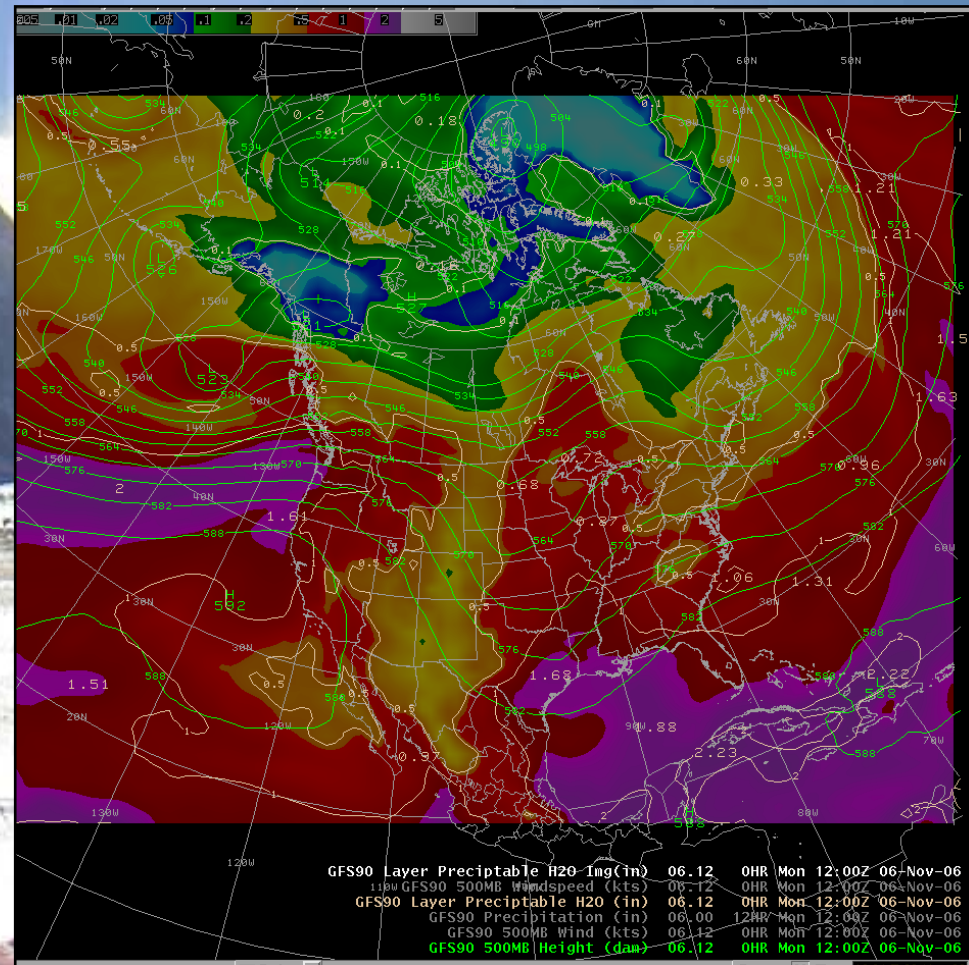
- Average wind speeds 20-30 mph
- Peak 80-120 during heaviest precip (6-7)



Warm and windy in area

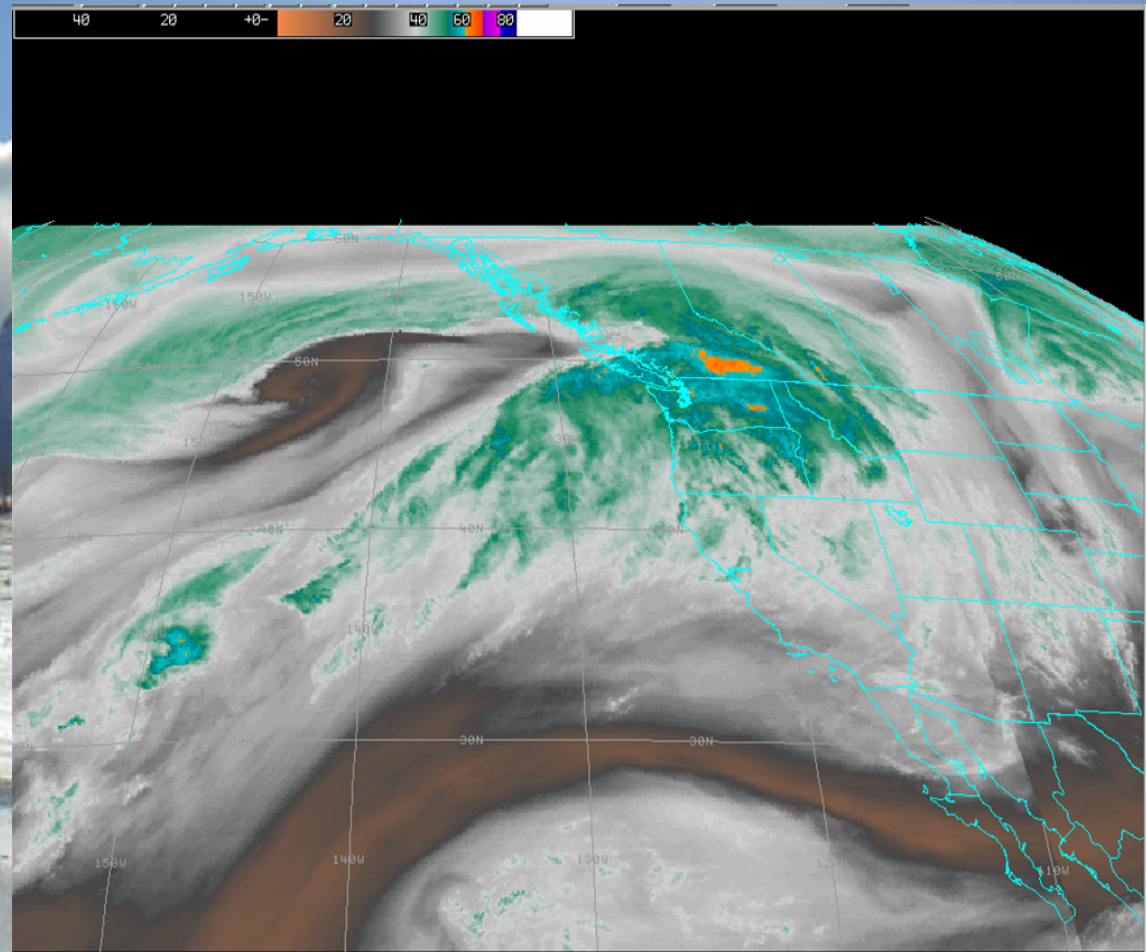
- **Record warmth and windy**
- **Nov 6**
 - Temp 69@ Helena
 - Wind 66 mph @ Two Medicine; 78 mph @ Deep Creek
 - Precip 0.43" @ Kalispell...new daily record.
- **Nov 7**
 - Temp 72@ Helena; 71 @ Havre
 - Warm lows 59@ Great Falls; 52@ Cut Bank
- **Nov 8**
 - Temp 62@ Missoula (record high)
- **No Record highs in Glacier Park, but very close.**

- Upper air pattern near onset of heavy precipitation. The precipitable water values in the model are quite high.
- On order of 2-3X normal

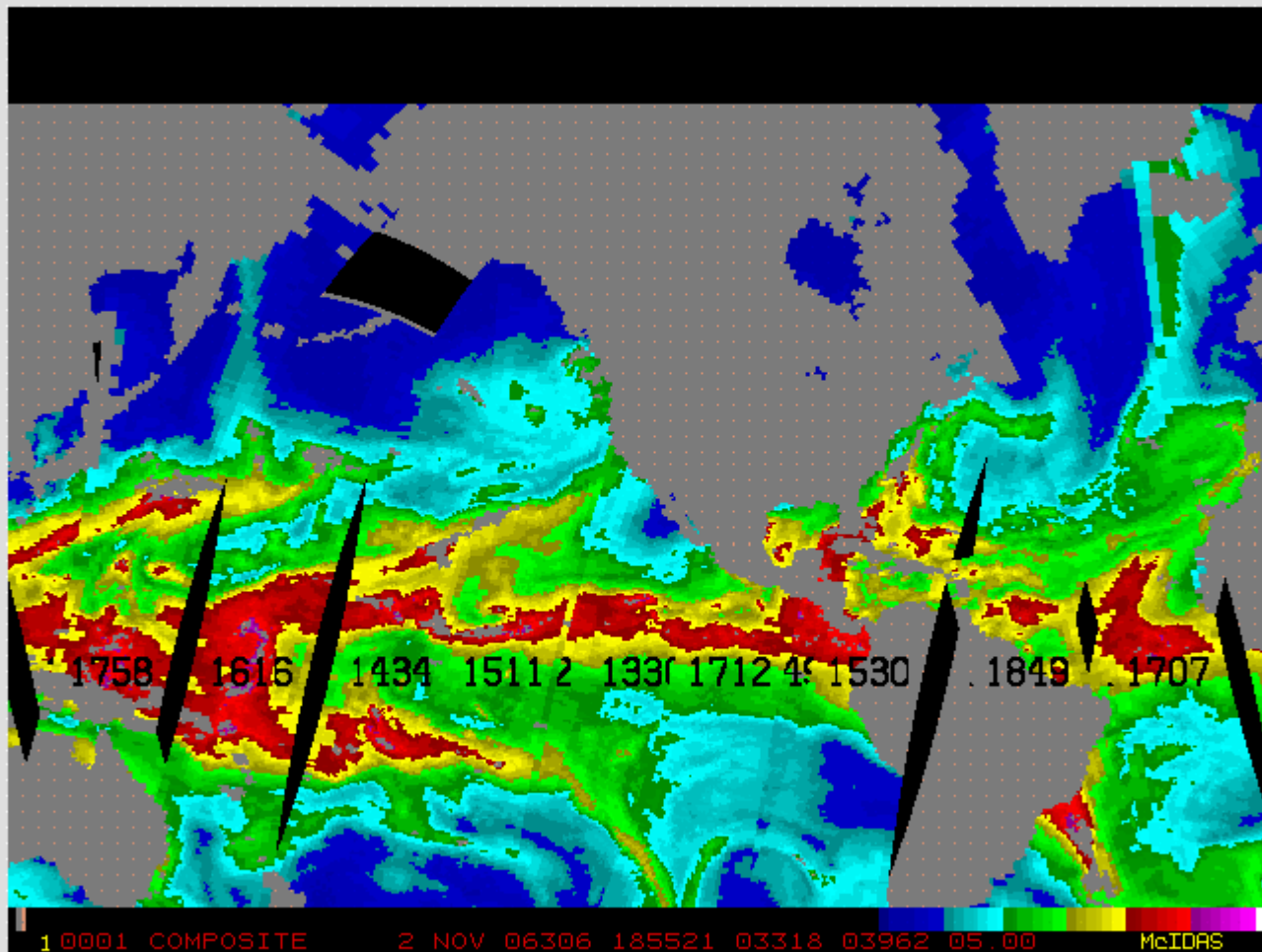


Monitoring Moisture

Satellite Nov 6 2006 06z



- AMSU loop...
 - Advanced Microwave Sounding Unit



Havre, MT

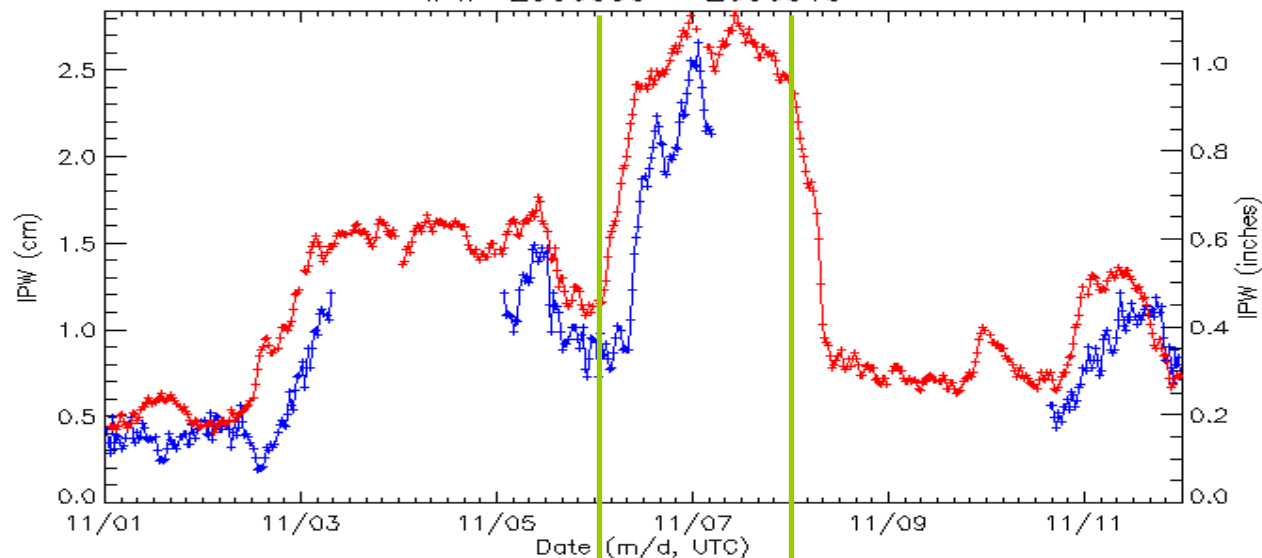
Polson, MT

Humidity: 53% Pressure: 30.54in

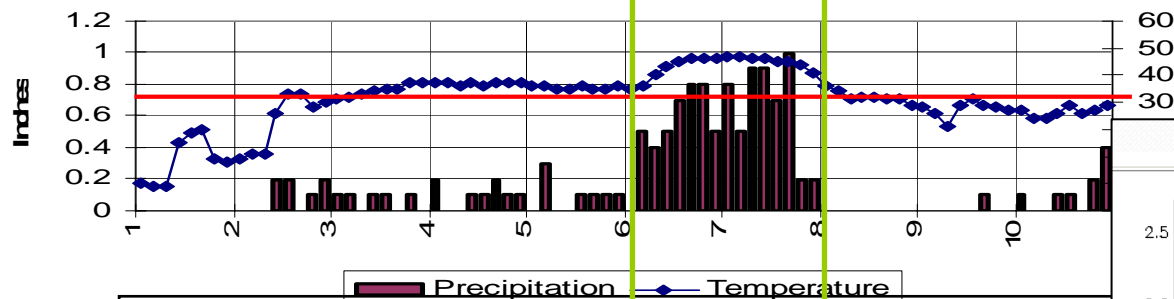
Exposure 51

IPW

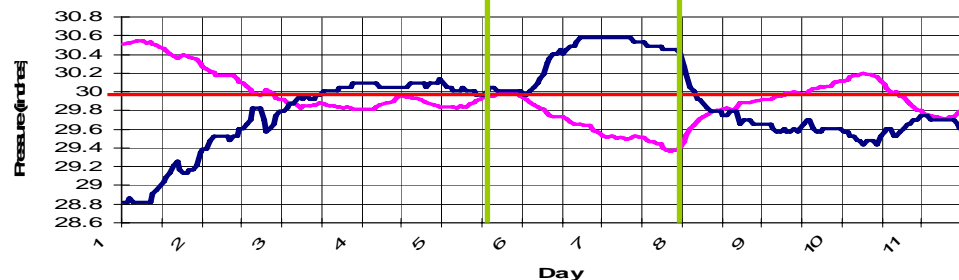
IPW 2006305 - 2006315



November 1-10, 2006



Logan Pass Temperature and Pressure
Nov 1-11, 2006 (elev. 6775 ft)

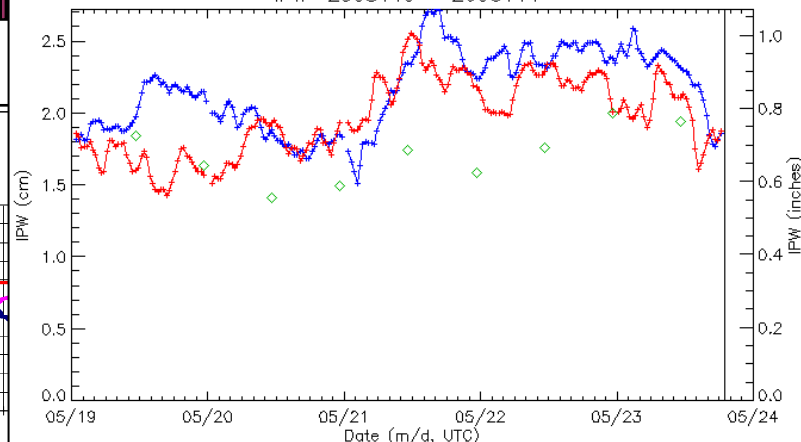


Billings, MT

Havre, MT

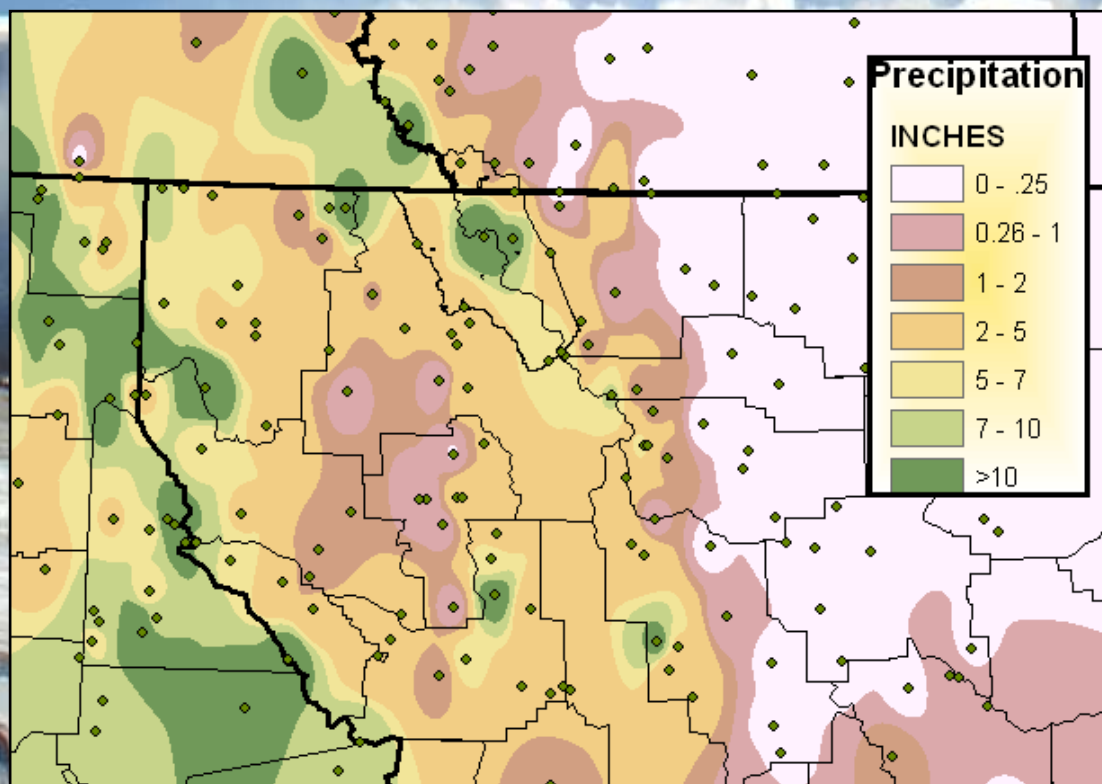
Great Falls, MT (RAOBS)

IPW 2008140 - 2008144

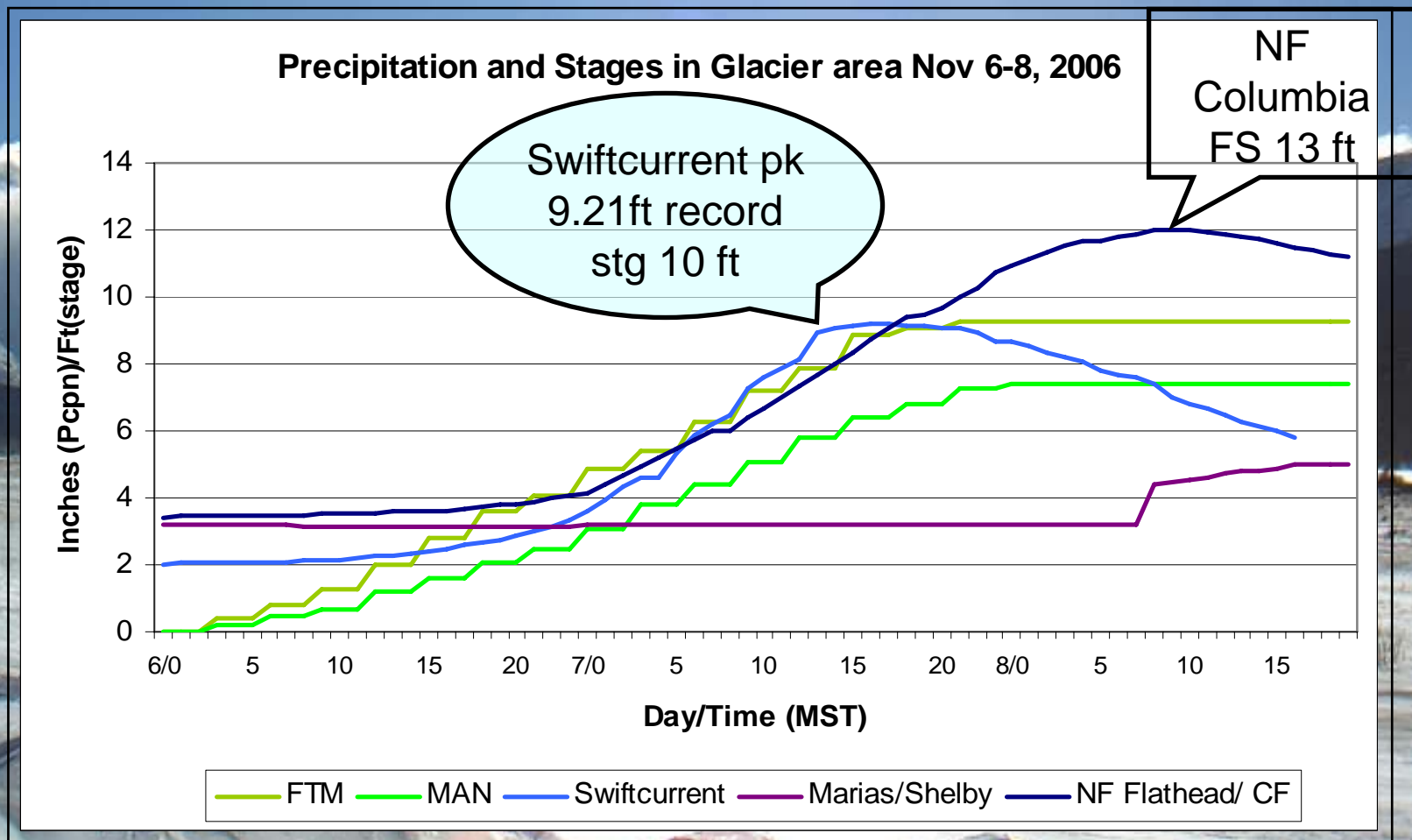


GSD, NOAA

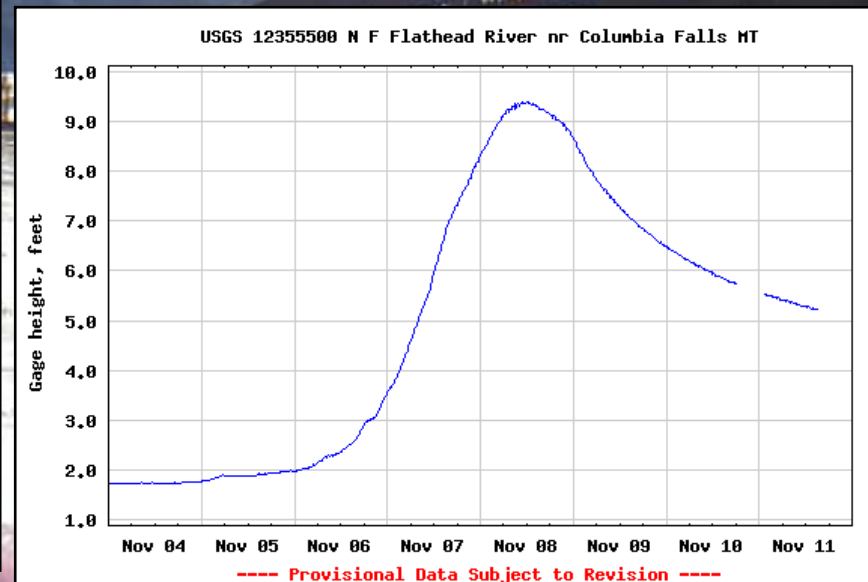
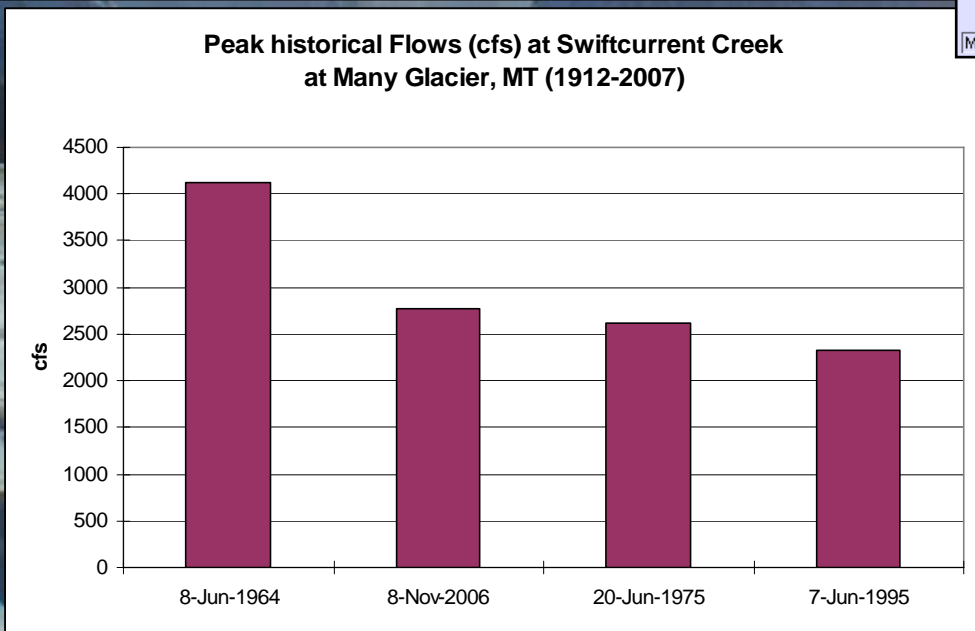
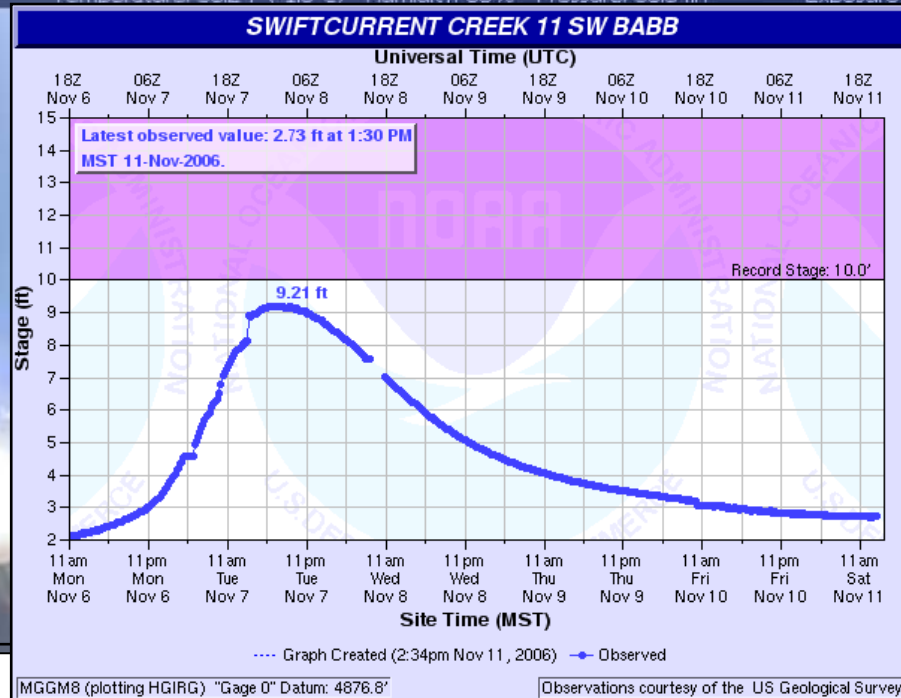
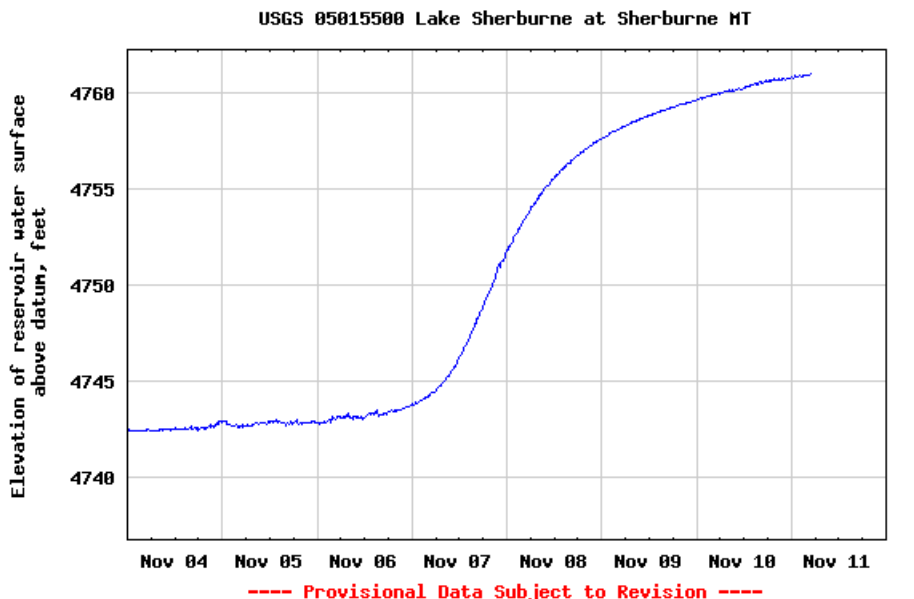
- Precipitation Nov 1-14 2006**



The response time was quick

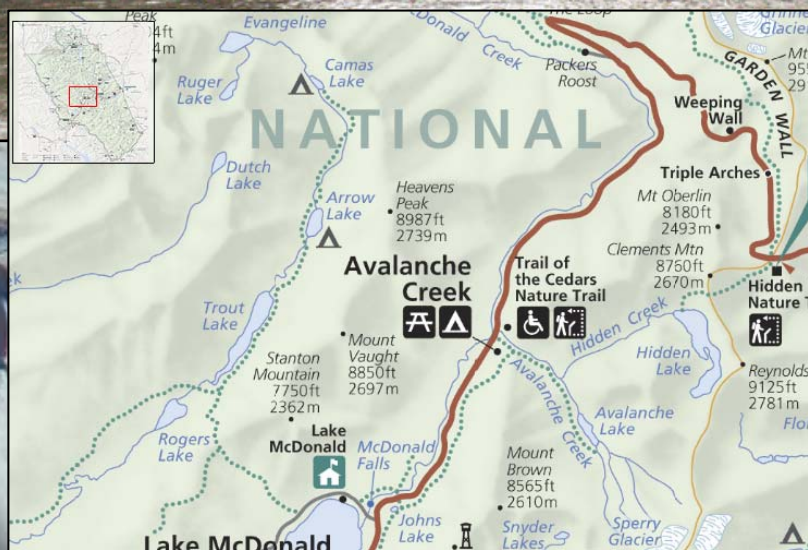
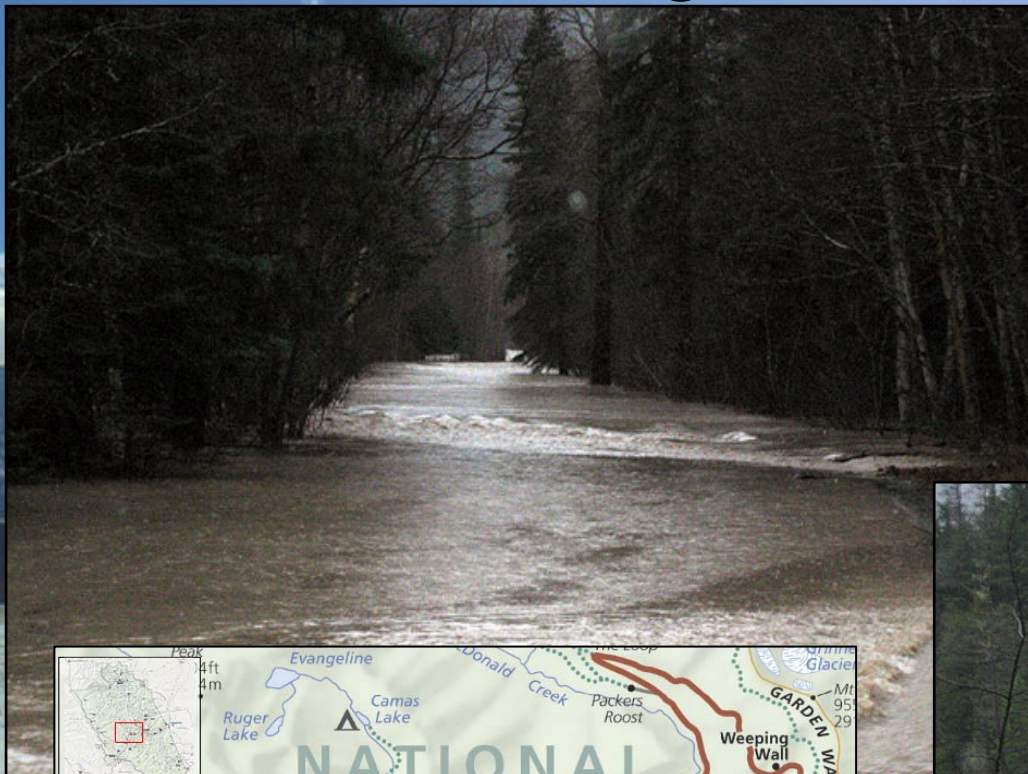


About 36h from precip onset 6" MAN/8" FTM to near record stage at Swiftcurrent



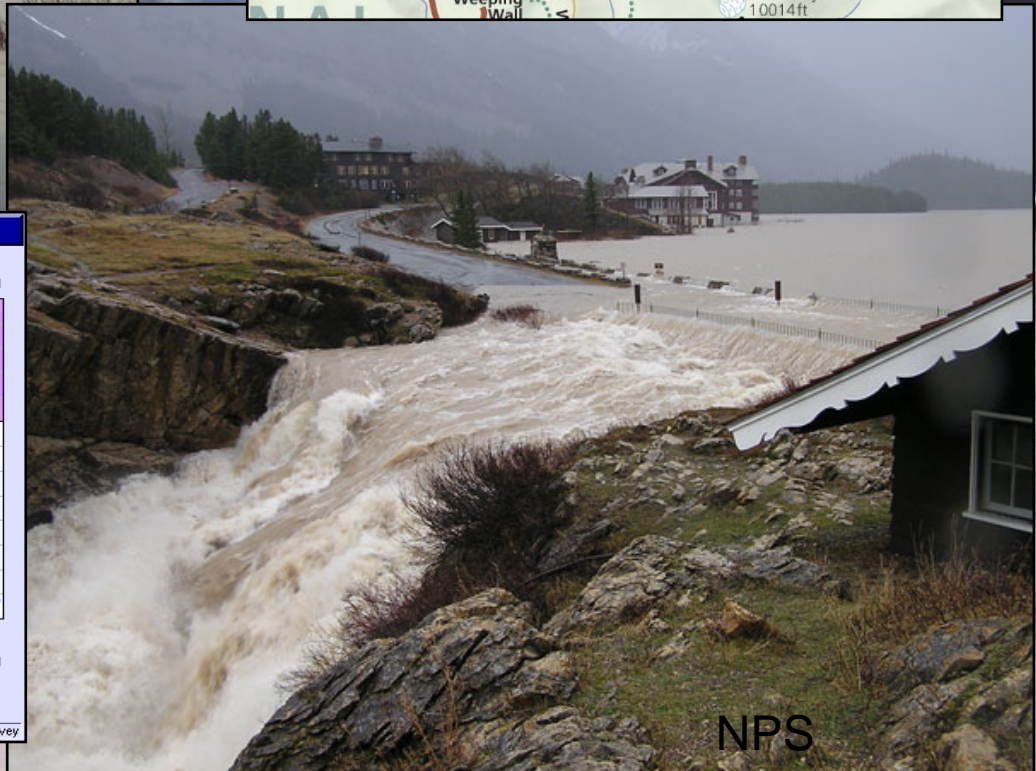
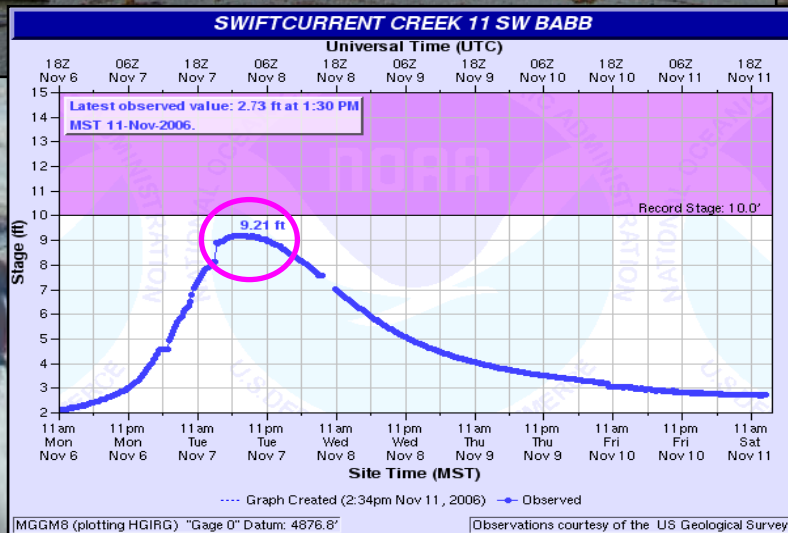
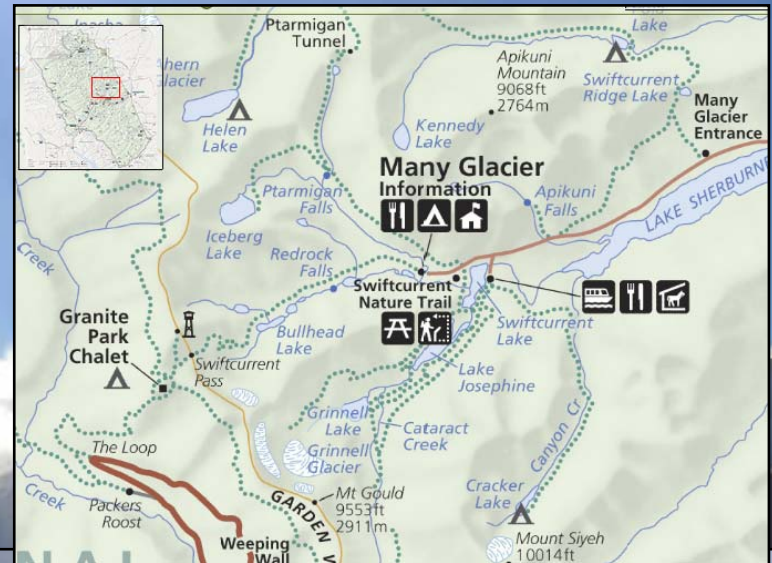
A mile above Avalanche Cr

...Horse bridge McDonald Ck 11/6/2006



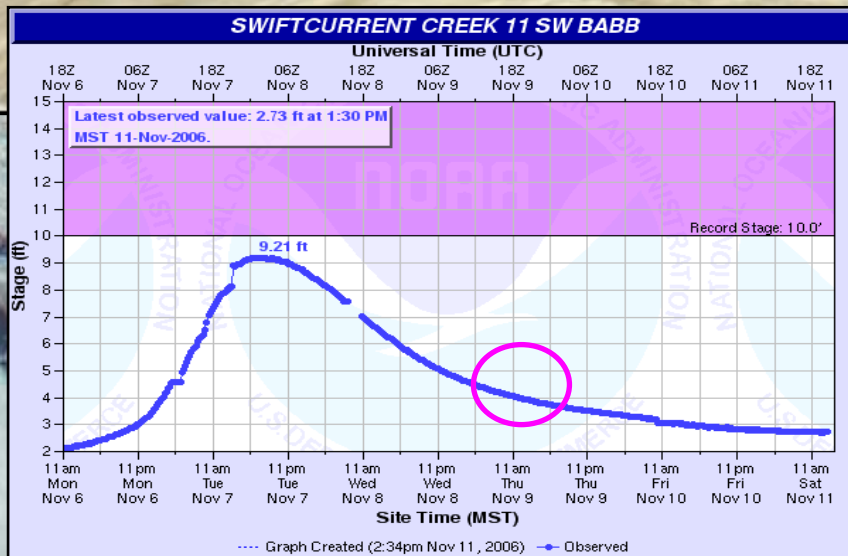
NPS

Many Glacier 11/7/2006



Many Glacier Bridge

11/9/2006



NPS

Many Glacier Hotel

11/9/2006

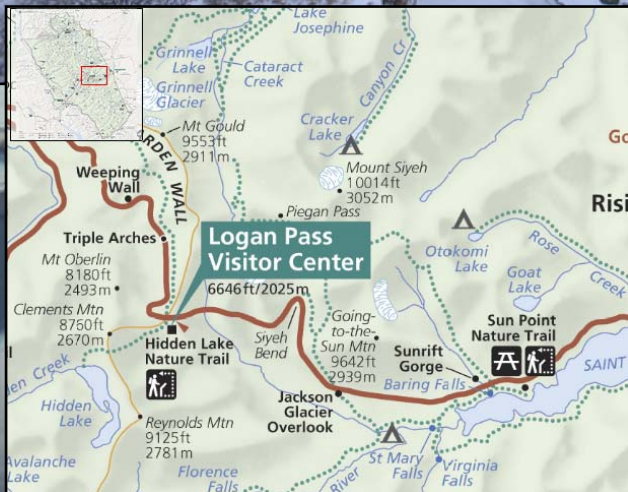


Washout on Going to Sun east side below tunnel 11/9/2006



East of eastside tunnel

11/9/2008

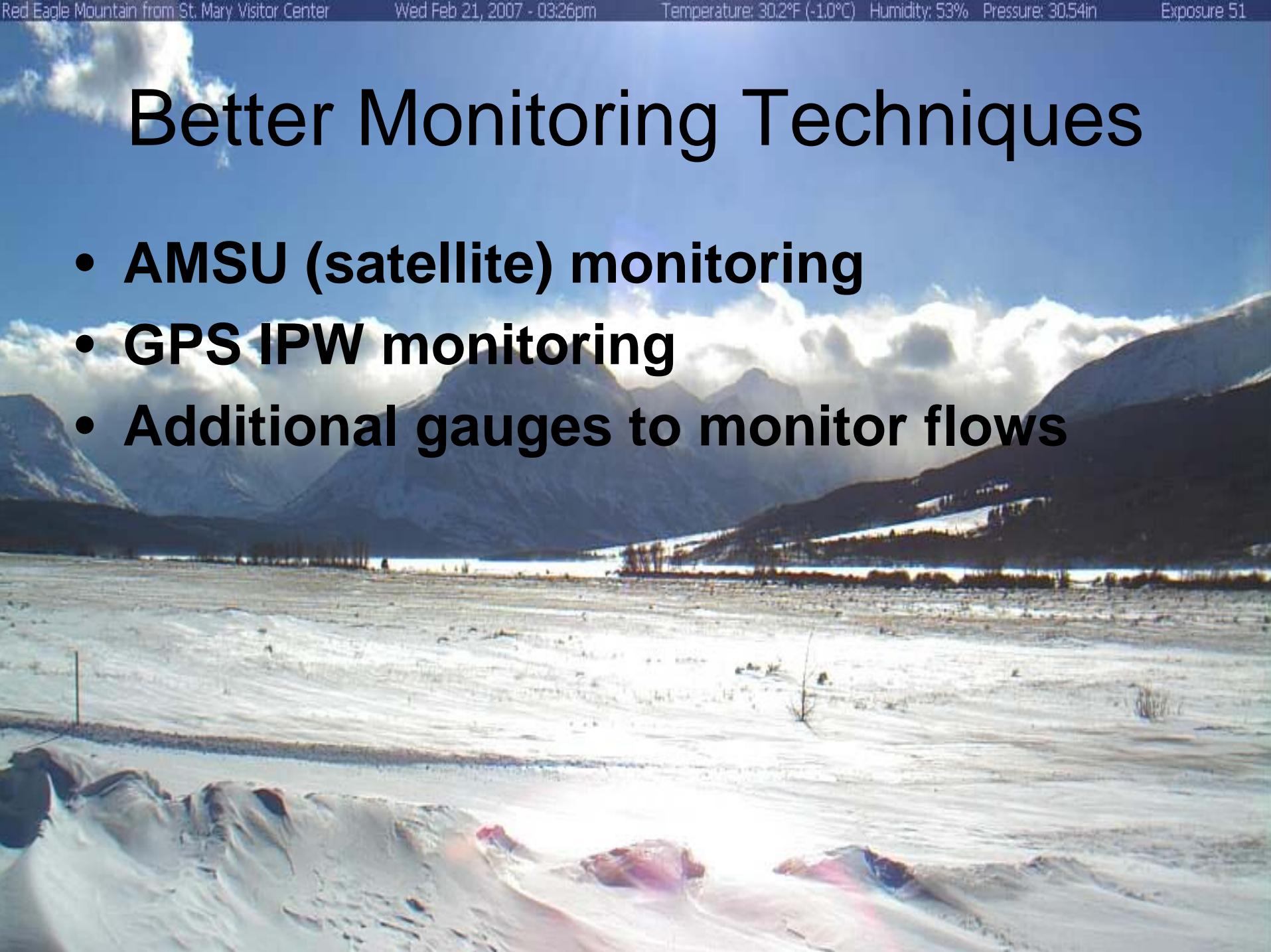


Summary

- **Very high precipitable water values**
- **Models had placement of max precip off**
 - Models undercut max precip, but had relatively high amounts
- **Out of season heavy rainfall**
- **Fell mostly as rain and melted existing snow**

Better Monitoring Techniques

- **AMSU (satellite) monitoring**
- **GPS IPW monitoring**
- **Additional gauges to monitor flows**



- **As the strongest of several disturbances moved through**
 - Added to strong upslope on windward side
 - Terrain effects
 - A strong jet streak

